

UNCLASSIFIED

**Defense Technical Information Center
Compilation Part Notice**

ADP023958

TITLE: Operationally Responsive Space: A Vision for the Future of Military Space

DISTRIBUTION: Approved for public release; distribution is unlimited.

This paper is part of the following report:

TITLE: Air & Space Power Journal Summer 2006

To order the complete compilation report, use: ADA503800

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:

ADP023952 thru ADP023966

UNCLASSIFIED



Editor's Note: PIREP is aviation shorthand for pilot report. It's a means for one pilot to pass on current, potentially useful information to other pilots. In the same fashion, we intend to use this department to let readers know about air and space power items of interest.

Operationally Responsive Space

A Vision for the Future of Military Space

LES DOGGRELL*

IN FUTURE CONFLICTS, military space forces will likely face challenges ranging from defending against opposing systems to dealing with rapidly changing technology and support needs. The Air Force describes its vision for responding to these challenges as operationally responsive space (ORS). Operations Desert Storm and Iraqi Freedom clearly demonstrated the force-multiplication effect of space systems on US military capabilities. Precision-guided munitions; global, high-speed communications; and enhanced situational awareness all contributed to the rapid destruction of the Iraqi military (fig. 1).¹ Unfortunately, future opponents observed the United States' dependence on space systems. To win the next war, this nation must prepare to respond to opposing space and counterspace systems. Gen Lance Lord, USAF, retired, former commander of Air Force Space Command, points to ORS as one way of shaping this response.² According to a draft study of ORS, it "will provide an affordable capability to promptly, accurately, and decisively position and operate national and military assets in and through space and near space. ORS will be fully integrated and interoperable with current and future architectures and provide space services and effects to war fighters and

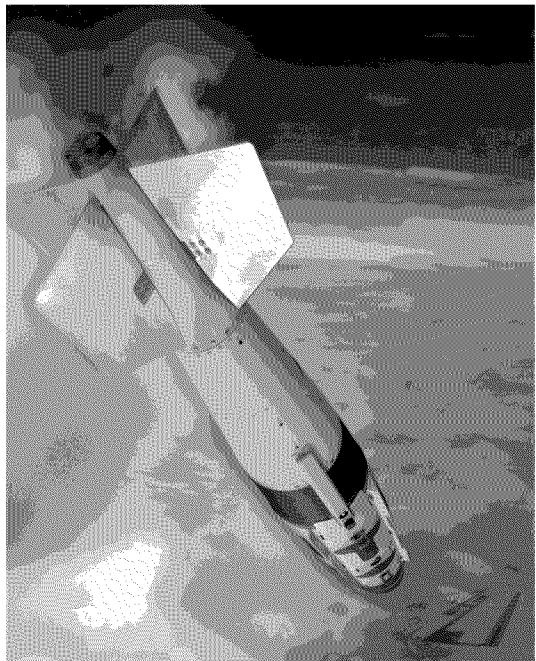


Figure 1. The Joint Direct Attack Munition (JDAM). Widely used during Iraqi Freedom, the JDAM uses the global positioning system (GPS), combined with an inertial system for navigation. Once released, the bomb guides to its target regardless of weather. (From the Boeing Company.)

*Mr. Doggrell is a senior project engineer with the Aerospace Corporation, supporting Headquarters Air Force Space Command's Directorate of Plans and Requirements, Peterson AFB, Colorado.

other users. ORS is a vision for transforming future space and near space operations, integration, and acquisition, all at a lower cost.”³

During Iraqi Freedom, described as the first counterspace war, both sides executed counterspace missions. Iraq, for example, attempted to jam GPS signals using Russian-made equipment, and US forces destroyed an enemy ground-transmitting facility, disabling Iraq’s ability to communicate with its forces and the outside world by using commercial satellite television.⁴ A more capable future opponent will find additional techniques for using space to counter the space capability of the United States.

We can anticipate some responses to our space systems. Specifically, Russia, North Korea, Iran, India, and China may be capable of building a nuclear-armed antisatellite weapon system.⁵ Furthermore, “many countries are developing advanced satellites for remote sensing, communications, navigation, imagery, and missile warning,” and Russia, China, and the European Union have developed or are developing satellite-navigation systems.⁶ Improved antijam features can counter jamming defenses. However, the most effective countermeasures to our space capability will likely take the form of unanticipated actions by our adversaries. Secretary of Defense Donald Rumsfeld might call such actions the “unknown unknowns” or, in the worst case, a “space Pearl Harbor.”⁷ Fortunately, we have military techniques for responding to the unknown. Speed, maneuverability, and agility have allowed military forces throughout history to deal with unanticipated events. The ability to act and respond faster than the enemy is a well-known tenet of military operations.

Space systems do not adapt well to change. When it became obvious in September 1990, during the planning for Desert Storm, that existing satellite-communications capacity would not support the war effort, we made an urgent attempt to launch an additional Defense Satellite Communications System III spacecraft. That mission finally launched on 11 February 1992, missing the war by over a year. Luckily for the nation, we not only had access to a retired spacecraft but also were able to hire com-

mercial communications capacity.⁸ The ability of the United States to support Iraqi Freedom with additional space capability has not significantly improved since Desert Storm.

President Bush has noted the need for responsive space capability. US Space Transportation Policy Directive 40, issued 6 January 2005, directs our government to “demonstrate an initial capability for operationally responsive access to and use of space—providing capacity to respond to unexpected loss or degradation of selected capabilities, and/or to provide timely availability of tailored or new capabilities—to support national security requirements.” The same document describes the purpose behind this direction: “Access to space through U.S. space transportation capabilities is essential to: (1) place critical United States Government assets and capabilities into space; (2) augment space-based capabilities in a timely manner in the event of increased operational needs or minimize disruptions due to on-orbit satellite failures, launch failures, or deliberate actions against U.S. space assets.”⁹ The challenge for the Air Force lies in responding to this direction within the constraints of austere budgets.

Responsiveness in space systems has proven difficult to attain. Characteristics of existing systems include development times exceeding a decade, high cost, and an emphasis on reliability and long mission life. These traits are driven, in part, by the considerable expense of getting to space. Nevertheless, we can achieve the space capability we desire through multiple approaches. The United States maintains a highly responsive fleet of launch vehicles in the ICBM force and has previously maintained communication spacecraft and counterspace systems on alert—an effective approach but costly and encumbered by nuclear politics.¹⁰ Consequently, ORS is examining avenues other than brute force to secure responsiveness. To do so, we must change many aspects of the entire space architecture. The ground system, space vehicle, launch vehicle, and launch infrastructure all affect the responsiveness of space capabilities (fig. 2). Improving a launch vehicle’s reaction time has little effect if we have not similarly improved the infrastructure and spacecraft.

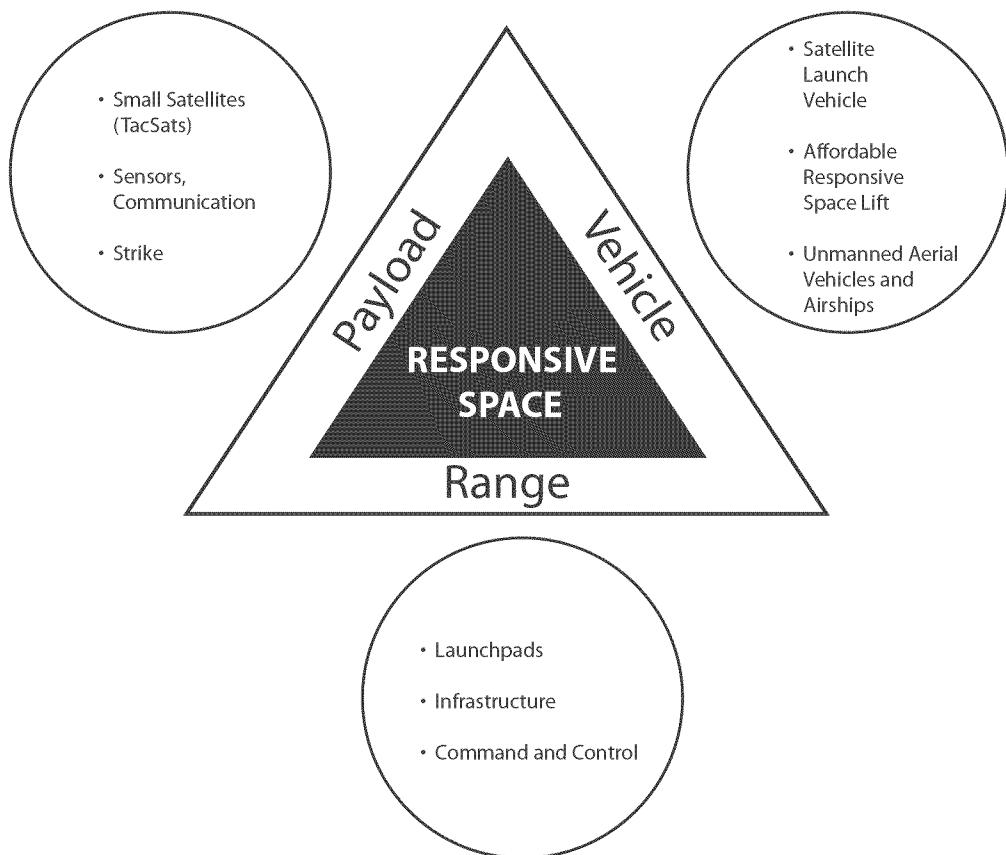


Figure 2. Responsiveness of space architecture. The ORS initiative divides improvements in responsiveness into categories that include the space vehicle, launch vehicle, and infrastructure. Improving each of these areas simultaneously presents a challenge. (From briefing, Lt Col Gus Hernandez, Headquarters Air Force Space Command [AFSPC], Directorate of Plans and Requirements, subject: ORS Overview, 7 March 2005.)

One approach entails not going to space at all since terrestrial systems or aircraft can meet many “space” needs. The Air Force identifies the domain above the typical operational altitudes for aircraft and below the orbital regime, roughly between 65,000 and 325,000 feet, as near space (fig. 3). This high altitude uniquely favors the deployment of intelligence, surveillance, and reconnaissance; battlespace situational awareness; and communications assets. Although we have not made extensive use of near space for military operations due to the technical challenges of operating in

this environment, advances in materials, solar collection, and power-storage technology can give the United States an opportunity to exploit this regime for persistent applications.¹¹

Spacecraft already on orbit can provide high levels of responsiveness to some types of requirements. Beginning with the end user, the process of tasking, posting, processing, and using data must be timely, flexible, and tightly integrated with the war fighter’s processing infrastructure and communications.¹² Centralized national processes task many existing high-demand, high-value space capabilities.

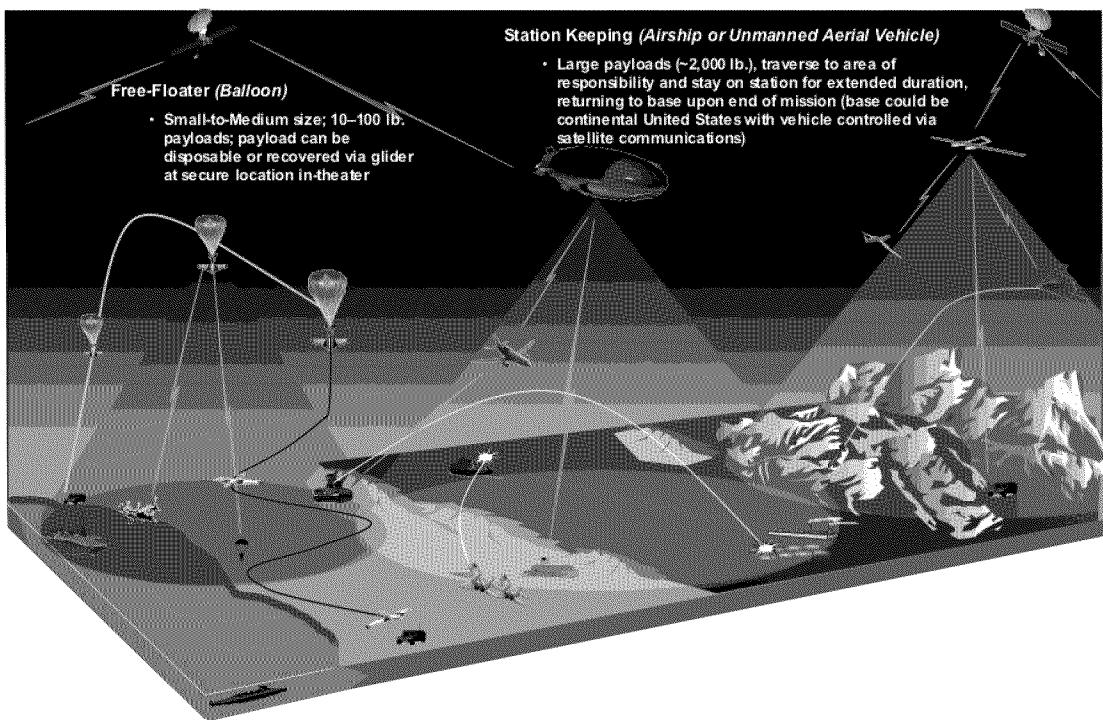


Figure 3. Operationally responsive space: view of near-space architecture. (From “Operationally Responsive Space/Near Space Initial Capabilities Document,” draft [Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.], app. A.)

The process of retasking a spacecraft must become responsive to a larger user community. Responsiveness applies as well to such actions as reorienting or maneuvering a spacecraft, modifying onboard software, or changing the pointing of the vehicle’s antenna.

We do not limit responsiveness to the space segment; launch can also improve the timeliness of meeting a new user need. Rapidly launching augmentation or replenishment spacecraft can prove essential to maintaining capability during a shooting counterspace war.¹³ Efficiently bringing a spacecraft online requires a reduction in initialization and checkout time, which in turn necessitates deliberate engineering to automate processes or eliminate intermediate steps. Currently we build spacecraft according to a launch-on-schedule concept, but responsive vehicles must prepare for

launch on demand. We can more effectively shift to the latter approach by maintaining an inventory of war-reserve materiel, spacecraft, and associated launch vehicles at the launch sites (fig. 4). Reaching farther back into the process, acceleration of the research, development, test, and acquisition phase can improve reaction to a new need or an evolving threat.

Because of the expense and risk of experimenting with major operational space systems, cost-reduction and risk-mitigation approaches need validation before commitment to a major acquisition program. The Air Force is exploring concepts for providing responsive capabilities using small spacecraft known as TacSats, relatively inexpensive vehicles weighing less than 1,000 pounds that hold promise as a proving ground for new concepts which enhance the responsiveness and survivability of

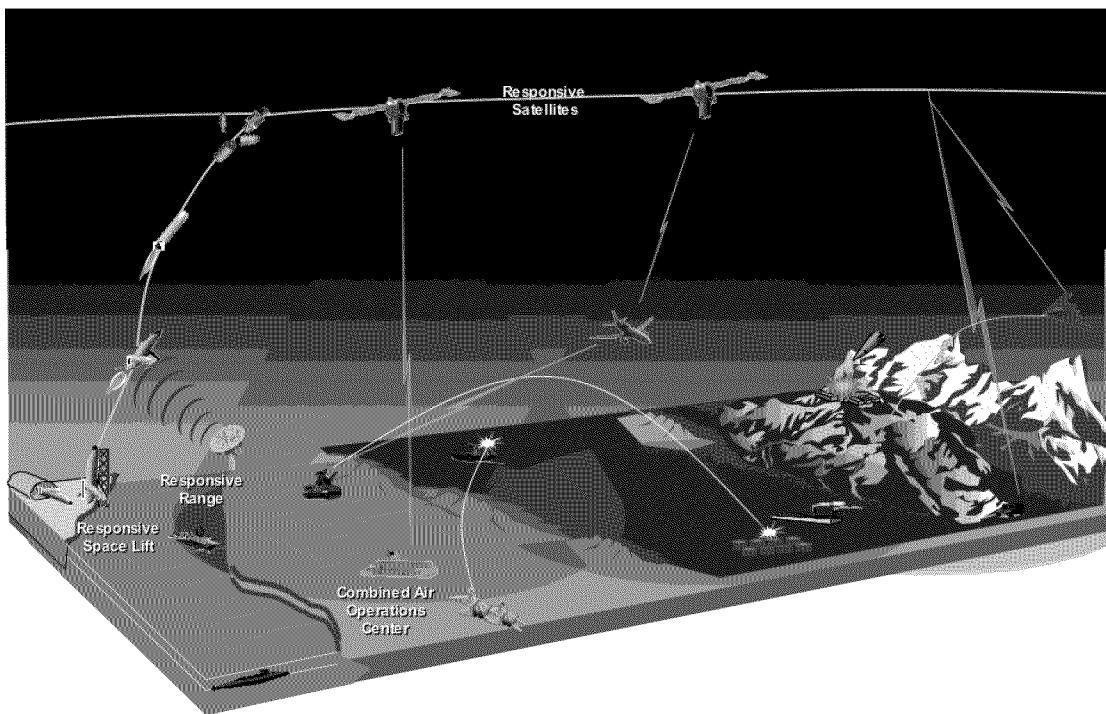


Figure 4. Operationally responsive space: view of satellite architecture. (From “Operationally Responsive Space/Satellite Initial Capabilities Document,” draft [Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.], app. A.)

future systems. Additionally, small spacecraft allow the possibility of designing distributed architectures featuring more spacecraft. By providing more but individually less critical targets, such architectures offer the potential to degrade gracefully in response to countermeasures such as antisatellite or ground-based jamming systems. TacSat spacecraft allow the Air Force to experiment with these concepts.

Spacecraft are notionally divided into two system segments: the payload and nonpayload support portions, known as the bus. Responsive spacecraft concepts include improving both of these. Advances in such technological areas as microelectronics could provide “big space” capability in a smaller package. TacSat 3, for example, will feature a hyperspectral-imaging payload and onboard target-recognition software. Existing space systems with long acquisition

cycles and on-orbit lifetimes have difficulty incorporating the latest technology, whereas shorter cycles and lifetimes encourage faster technology refreshment in the space segment.

More, smaller spacecraft launched on shorter mission timelines may have additional benefits. The small number of spacecraft and launch vehicles currently produced by the United States complicates the maintenance of an industrial base and increases the unit cost of each craft and vehicle. Convincing the military space industry, which drives the manufacture of high-reliability, radiation-tolerant parts, to continue this production at any price for only a few units per year poses a considerable challenge. Producing relatively few units means that the costs of each are dominated by the “standing army” or the fixed expense of maintaining a capability. For example, the price of

owning infrastructure such as a launchpad or a vacuum test chamber remains largely independent of the frequency of use. The expense of maintaining specialized expertise becomes fixed as well when production rates stay low. Thus, larger numbers of spacecraft and launch vehicles, even smaller ones, might result in economic production quantities and cost-reduction benefits, which in turn would allow exploration of new missions or new approaches to existing missions.¹⁴

The TacSat series of spacecraft is also exploring alternative spacecraft bus-design concepts. By departing from typical spacecraft design (weight optimized and highly customized for the intended application) and instead designing common, modular, standard, or plug-and-play spacecraft buses, we could reduce the cost of the development and production schedule and, consequently, that of the fleet itself.¹⁵ Production rate and operational concept highly influence the trade-off between efficiencies gained through commonality, standardization, and modularity and the place in production flow where we should make such trades. Spacecraft bus concepts offer the possibility of instantly customizing a spacecraft to meet a specific need on an accelerated timeline while keeping costs below existing equivalent-capability costs. For example, a plug-and-play concept may allow selection of the specific spacecraft payload at the launch site. However, preintegrated and tested spacecraft would expedite and simplify launch-site procedures.

Several launch-vehicle designs offer potential improvements to responsiveness. Small launch vehicles, designed as part of the Air Force's/ Defense Advanced Research Projects Agency's Force Application Launch from the Continental United States program, offer the prospect of greatly reducing the time and cost of delivering a small spacecraft to orbit. The Space and Missile Systems Center at Los Angeles AFB is developing a new class of launch vehicles that can reduce cost and improve the responsiveness of space launch. The Affordable Responsive Spacelift (ARES) concept, a hybrid configuration, contains a reusable first stage with expendable upper stages (fig. 5). The reusable booster stage accelerates the expendable

stages and payload to a separation point in near space. The separated expendable stages provide the remaining impulse to inject the payload into orbit. The reusable booster returns to the launch base to be prepared for the next flight. Cost analyses by the government and industry have shown repeatedly the advantage of fully reusable launch vehicles over expendable launch systems in terms of cost-effectiveness. However, fully reusable solutions require very high flight rates to offset development cost. Additionally, as demonstrated by several attempts, the design of a fully reusable launch vehicle has proven technically daunting. The hybrid ARES concept offers a means of exploring the usefulness of a partially reusable launch concept at low up-front cost and risk.

Both launch vehicles and spacecraft require ground infrastructure. In the case of the former, the Air Force operates extensive, fixed coastal facilities at Vandenberg AFB, California, and Cape Canaveral AFS, Florida, which need major upgrades and may be easy targets for opposing counterspace forces. Transportable launch infrastructure, however, which could operate from alternate locations, offers a means of avoiding the lengthy, expensive planning required to resolve safety issues and to use the existing infrastructure. On the spacecraft side, ground-control and data-processing costs can exceed those of the spacecraft. Responsive systems must exploit existing military and commercial infrastructure in order to keep the effect of costs and logistics manageable. Developing austere ground systems that can react rapidly will prove challenging.

Development of responsive space may in turn enable new concepts. We could use a highly responsive and inexpensive space-launch capability to precisely deliver conventional ordnance anywhere in the world (a Prompt Global Strike system). Low-cost spacecraft could enable space systems to provide direct support to the operational and tactical levels of warfare, as envisioned by the Air Force's concept document on joint war-fighting space.¹⁶ Development of quick-response spacecraft capable of augmenting existing capabilities might allow transition to an expeditionary space forces

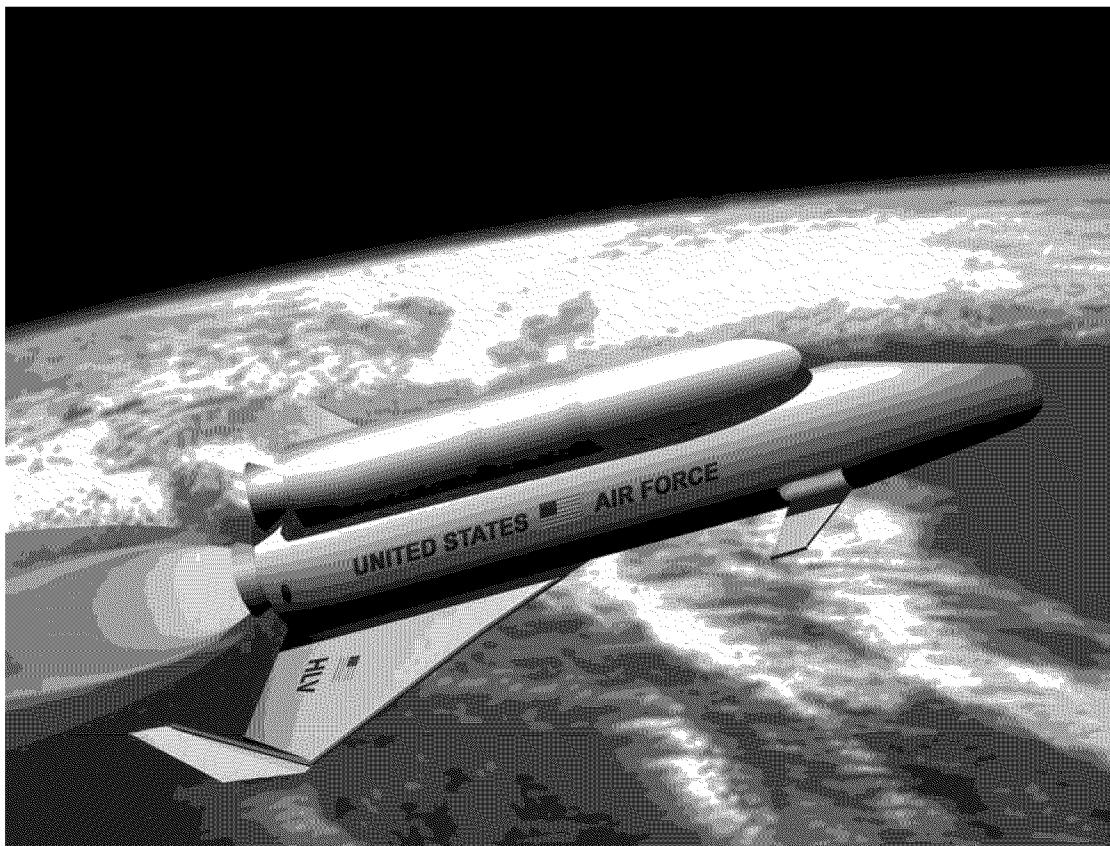


Figure 5. ARES vehicle. The ARES concept calls for a vehicle with a reusable first stage and expendable upper stages (also known as a hybrid launch vehicle). (Courtesy USAF.)

concept whereby we deploy the full system capability only when needed. Counterspace missions will benefit from improvements to small spacecraft and responsive-launch technologies associated with ORS. Ultimately, technologies that improve the responsiveness of new missions and small spacecraft will transform the way we perform traditional space missions.

Changing the way space professionals think about space systems may prove the most formidable obstacle to creating a more responsive space system. Some people perceive current systems as high-value assets that we must protect—not consume. Deciding whether or not to shorten the projected mission life of an existing spacecraft by using onboard fuel to move the spacecraft in support of a contin-

gency will have national implications. In the future, operators of responsive space systems will need to react to the changing needs of US forces and to the actions of opposing forces in a dynamic, timely fashion. Initiatives such as the National Security Space Institute, which shapes future space leaders, may be more important than technology development in the long run (fig. 6).

Future adversaries will inevitably take steps to counter US space capabilities. At the same time, technology will continue to shape the evolution of military space systems. Improvements in the responsiveness of space systems give us the means of proactively engaging these future changes. □

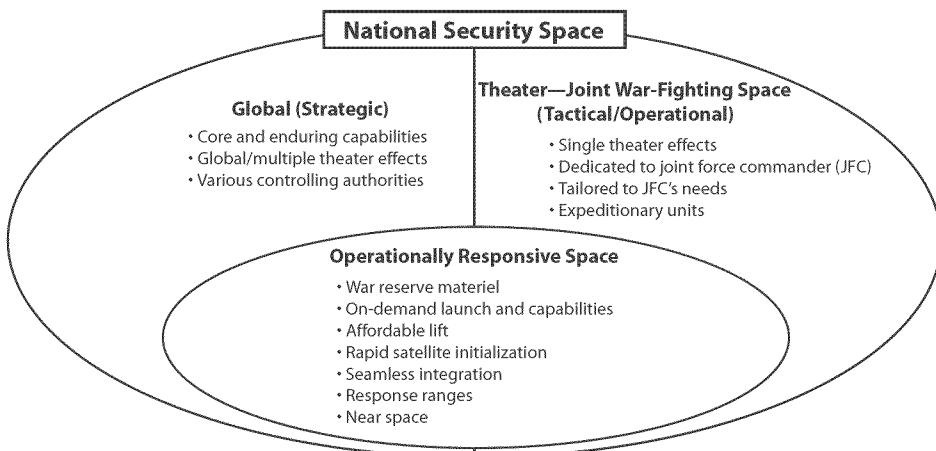


Figure 6. Relationship among ORS, strategic space, and tactical space. (From briefing, Lt Col Gus Hernandez, Headquarters AFSPC, Directorate of Plans and Requirements, subject: ORS Overview, 7 March 2005.)

Notes

1. During Iraqi Freedom, the global positioning system precision-guided more than 25 percent of the munitions expended. Lt Gen T. Michael Moseley, USAF, commander, USCENTAF, *Operation Iraqi Freedom—By the Numbers* (Shaw AFB, SC: USCENTAF/PSAB, 30 April 2003), http://www.globalsecurity.org/military/library/report/2003/uscentaf_oif_report_30apr2003.pdf.

2. Gen Lance Lord, commander, Air Force Space Command, White Paper (Peterson AFB, CO: Headquarters AFSPC, 23 August 2004), 1.

3. "Operationally Responsive Space/Launch Vehicle Initial Capabilities Document," draft (Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.), 3.

4. Jeremy Singer, "U.S.-Led Forces Destroy GPS Jamming Systems in Iraq," *Space News*, 25 March 2003.

5. Lt Col Clayton K. S. Chun, *Shooting Down a "Star": Program 437, the US Nuclear ASAT System and Present-Day Copycat Killers*, CADRE Paper no. 6 (Maxwell AFB, AL: Air University Press, April 2000), 32, http://aupress.au.af.mil/CADRE_Papers/PDF_Bin/chun.pdf.

6. *Challenges to US Space Superiority*, NASIC-1441-3894-05 (Wright-Patterson AFB, OH: National Air and Space Intelligence Center, March 2005), 2, http://www.armscontrolwonk.com/Challenges_to_Space_Superiority.pdf.

7. In 2001 the Rumsfeld Commission recognized the threat: "If the US is to avoid a 'space Pearl Harbor,' it needs to take seriously the possibility of an attack on US space systems." Jean-Michel Stoullig, "Rumsfeld Commission Warns against 'Space Pearl Harbor,'" *SpaceDaily*, 11 January 2001, <http://www.spacedaily.com/news/bmdo-01b.html>.

8. David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership*, rev. ed. (Peterson AFB, CO: Air Force Space Command in association with Air University Press, 1998), 247.

9. "Fact Sheet: U.S. Space Transportation Policy, January 6, 2005," n.p., <http://www.ostp.gov/html/SpaceTransFactSheetJan2005.pdf>.

10. See Chun, *Shooting Down a "Star"*, 32.

11. "Operationally Responsive Space/Near Space Initial Capabilities Document," draft (Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.), 3.

12. The network-centered approach of tasking, posting, processing, and using as opposed to the tasking, processing, exploiting, and disseminating process emphasizes making raw data available to a variety of users for analysis instead of fully analyzed products that are centrally distributed. Regardless of method, the emphasis of ORS remains on accelerating the response of the process.

13. "ORS Analysis of Alternatives" (Peterson AFB, CO: Headquarters AFSPC, Directorate of Plans and Requirements, n.d.).

14. Dr. Pedro "Pete" Rustan, director of the National Reconnaissance Office's Advanced Systems and Technology Office, is well known for advocating this style of approach. He did so, for example, in his keynote address to the Third Responsive Space Conference in Los Angeles on 27 April 2005.

15. Douglas E. Lee, "Space Reform," *Air and Space Power Journal* 18, no. 2 (Summer 2004): 103–12, <http://www.airpower.maxwell.af.mil/airchronicles/apj/apj04/sum04/sum04.pdf>.

16. "Joint Warfighting Space (JWS): The vision for JWS is a fully capable expeditionary space force, ready and responsive to theater warfighters' needs, bringing the full impact of space/near-space capabilities to the operational and tactical levels of war." "USAF Operating Concept for JWS" (Peterson AFB, CO: Headquarters AFSPC, Directorate of Air and Space Operations, January 2005).